The Impact of Climate Change on Agriculture (yojana) Aug 2006

**Climate change would strongly affect agriculture, but scientists still don’t know exactly how.** Most agricultural impacts studies are based on the results of [general circulation models](http://www.cs.ntu.edu.au/homepages/jmitroy/sid101/uncc/fs014.html) (GCMs). These climate models indicate that rising levels of greenhouse gases are likely to increase the global average surface temperature by 1.5-4.5 C over the next 100 years, [raise sea-levels](http://www.cs.ntu.edu.au/homepages/jmitroy/sid101/uncc/fs102.html) (thus inundating farmland and making coastal groundwater saltier), [amplify extreme weather events](http://www.cs.ntu.edu.au/homepages/jmitroy/sid101/uncc/fs105.html) such as storms and hot spells, shift climate zones poleward, and reduce soil moisture. [Impacts studies](http://www.cs.ntu.edu.au/homepages/jmitroy/sid101/uncc/fs122.html) consider how these general trends would affect agricultural production in specific regions. To date, most studies have assumed that agricultural technology and management will not improve and adapt. New studies are becoming increasingly sophisticated, however, and "adjustments experiments" now incorporate assumptions about the human response to climate change.

**Increased concentrations of CO2 may boost crop productivity.** In principle, higher levels of CO**2** should stimulate photosynthesis in certain plants; a doubling of CO**2** may increase photosynthesis rates by as much as 30-100%. Laboratory experiments confirm that when plants absorb more carbon they grow bigger and more quickly. This is particularly true for C3 plants (so called because the product of their first biochemical reactions during photosynthesis has three carbon atoms). Increased carbon dioxide tends to suppress photo-respiration in these plants, making them more water-efficient. C3 plants include such major mid-latitude food staples as wheat, rice, and soya bean. The response of C4 plants, on the other hand, would not be as dramatic (although at current CO**2** levels these plants photosynthesize more efficiently than do C3 plants). C4 plants include such low-latitude crops as maize, sorghum, sugar-cane, and millet, plus many pastures and forage grasses.

**Climate and agricultural zones would tend to shift towards the poles.** Because average temperatures are expected to increase more near the poles than near the equator, the shift in climate zones will be more pronounced in the higher latitudes. In the mid-latitude regions (45 to 60 latitude), the shift is expected to be about 200-300 kilometers for every degree Celsius of warming. Since today’s latitudinal climate belts are each optimal for particular crops, such shifts could have a powerful impact on agricultural and livestock production. Crops for which temperature is the limiting factor may experience longer growing seasons.

**While some species would benefit from higher temperatures, others might not.** A warmer climate might, for example, interfere with germination or with other key stages in their life cycle. It might also [reduce soil moisture](http://www.cs.ntu.edu.au/homepages/jmitroy/sid101/uncc/fs104.html); evaporation rates increase in mid-latitudes by about 5% for each 10C rise in average annual temperature. Another potentially limiting factor is that soil types in a new climate zone may be unable to support intensive agriculture as practiced today in the main producer countries. For example, even if sub-Arctic Canada experiences climatic conditions similar to those now existing in the country’s southern grain-producing regions, its poor soil may be unable to sustain crop growth.

**Mid-latitude yields may be reduced by 10-30% due to increased summer dryness.** Climate models suggest that today’s leading grain-producing areas - in Asia and Africa may experience more frequent droughts and heat waves by the year 2030. Extended periods of extreme weather conditions would destroy certain crops, negating completely the potential for greater productivity through "CO**2** fertilization". The poleward edges of the mid-latitude agricultural zones - northern Canada, Scandinavia, Russia, and Japan in the northern hemisphere, and southern Chile and Argentina in the southern one - may benefit from the combined effects of higher temperatures and CO**2** fertilization. But the problems of rugged terrain and poor soil suggest that this would not be enough to compensate for reduced yields in the more productive areas.

**The impact on yields of low-latitude crops is more difficult to predict.** While scientists are relatively confident that climate change will lead to higher temperatures, they are less sure of how it will affect precipitation - the key constraint on low-latitude and tropical agriculture. Climate models do suggest, however, that the inter-tropical convergence zones may migrate poleward, bringing the monsoon rains with them. The greatest risks for low-latitude countries, then, are that reduced rainfall and soil moisture will damage crops in [semi-arid regions](http://www.cs.ntu.edu.au/homepages/jmitroy/sid101/uncc/fs103.html), and that additional heat stress will damage crops and especially livestock in humid tropical regions.

[**The impact on net global agricultural productivity**](http://www.cs.ntu.edu.au/homepages/jmitroy/sid101/uncc/fs127.html) **is also difficult to assess.** Higher yields in some areas may compensate for decreases in others - but again they may not, particularly if today’s major food exporters suffer serious losses. In addition, it is difficult to forecast to what extent farmers and governments will be able to adopt new techniques and management approaches to compensate for the negative impacts of climate change. It is also hard to predict how relationships between crops and pests will evolve.

**Adaptation**

A wide variety of adaptive actions may be taken to lessen or overcome adverse effects of climate change on agriculture. At the level of farms, adjustments may include the introduction of later- maturing crop varieties or species, switching cropping sequences, sowing earlier, adjusting timing of field operations, conserving soil moisture through appropriate tillage methods, and improving irrigation efficiency. Some options such as switching crop varieties may be inexpensive while others, such as introducing irrigation (especially high-efficiency, water-conserving technologies), involve major investments. Economic adjustments include shifts in regional production centers and adjustments of capital, labor, and land allocations. For example, trade adjustments should help to shift commodity production to regions where comparative advantage improves; in areas where comparative advantage declines, labor and capital may move out of agriculture into more productive sectors. Studies combining biophysical and economic impacts show that, in general, market adjustments can indeed moderate the impacts of reduced yields.

A major adaptive response will be the breeding of heat- and drought-resistant crop varieties by utilizing genetic resources that may be better adapted to new climatic and atmospheric conditions. Collections of such genetic resources are maintained in germ-plasm banks; these may be screened to find sources of resistance to changing diseases and insects, as well as tolerances to heat and water stress and better compatibility to new agricultural technologies. Crop varieties with a higher harvest index (the fraction of total plant matter that is marketable) will help to keep irrigated production efficient under conditions of reduced water supplies or enhanced demands. Genetic manipulation may also help to exploit the beneficial effects of CO2 enhancement on crop growth and water use.